

On some Earthworms from Perlis and Kedah

By G. E. GATES

Since publication of the previous article in this journal three small collections have been received from the Raffles Museum of which those from the northernmost states of Perlis and Kedah are of especial interest. With the exception of specimens of two peregrine species all of the worms again belong to species of *Pheretima*. All northern species, with possibly one exception, appear to be endemic.

The range of *P. indica* can now be extended northwards nearly to the upper border of British territory, of the Burmese *mamillana* southwards just into British territory while that of *annandalei*, hitherto known only from a Siamese portion of the peninsula, is extended into the Malay States. Two peninsular species, hitherto known only from the types can now be more adequately characterized (with certain reservations as to one) and their ranges slightly extended. Unfortunately most if not all of the Skeat expedition species are inadequately characterized. Until types of these species have been satisfactorily diagnosed or extensive collections from type localities have been studied certain questions as to definition or nomenclature will remain unanswered.

Material of the present collections, at best, is only in fair condition, the structures most damaged by the maceration being subneural trunks (usually quite unrecognizable), lymph glands (usually unrecognizable anteriorly and occasionally even posteriorly), the glandular collar on the oesophagus just behind the gizzard and occasionally even the blood glands. As there is some evidence to indicate that certain characteristics of the vascular system may be of importance in determination of interspecific relationships within the genus *Pheretima*, some description of the system is given in connection with each species. In these accounts there is no pretence of a description of the circulatory system, all that is possible is an indication of the characteristics and relationships of the major vessels as recognizable in the particular specimens that have been studied.

In an earlier article in this journal (Gates 1936) it was pointed out that the species of *Pheretima* from Pahang are remarkably uniform with regard to certain characteristics, most important of which perhaps is the presence of a complete septum 8/9 or of 8/9 and 9/10. In only one of the northern species, and that decithecate, is 8/9 complete. The majority of the northern species (excluding the multithecal forms which are unrepresented in the present collections) are octothecal and penile.

In a recent note on "*Endogone* as animal food" (Science, XC, p. 442, 1939) there is a statement to the effect that earthworms "would have difficulty in swallowing refractory objects" of a diameter of one quarter mm. In this particular case the material under discussion may be refractory, i.e., unmanageable by earthworms but surely not because of the large size. Particles of rock and bits of plant material quite definitely larger than the limit suggested have been found very frequently in guts of Oriental earthworms no larger than or not as large as the commoner North American forms. In the first two worms (*P. annandalei*) opened after reading the note mentioned above, a twig one half mm. in diameter was found in the oesophagus of each specimen, one twig six mm. long the other about five mm. long, each twig with stumps of lateral branches.

Family MEGASCOLECIDAE

Genus *Pheretima* Kinberg*Pheretima annandalei* Stephenson.

Pheretima annandalei Stephenson 1917, Rec. Ind. Mus. Calcutta, XIII, p. 386. (Type locality Singgora, Tale Sap, Siam. Type in the Indian Museum.)

Kaki Bukit, Perlis. 12/1938. 6 clitellate specimens.

External characteristics.—Length 125–170 mm. Diameter five to seven mm. Pigmentation red, restricted to dorsum, dense anterior to the clitellum, gradually fading out behind the clitellum.

Setae begin on ii on which segment there are usually several gaps in which apertures of follicles may be recognizable. Formulae of three specimens with paired patches of genital markings are shown below.

SETAL FORMULAE

vi	vii	viii	xvii	xviii	xix	ii	iii	viii	xii	xi
43	44	40+24	17	13	19	24+	39	64	66	70
35	35	39+23	19	14	16	25+	33+	62	59	60
35	34	36+20	14	10	17	28+	36+	56	60	58

The first dorsal pore is on 11/12 (1) or 12/13 but with a more or less pore-like and possibly perforate marking on 11/12 (5).

The clitellum is dark grey, annular, extending from 13/14 to 16/17; intersegmental furrows, dorsal pores and setae lacking.

Spermathecal apertures are transversely placed slits on 5/6-8/9, on the dorsum but fairly widely separated. Immediately anterior to each spermathecal pore is a half-moon-shaped area of epidermal whitening. A smaller and less obvious area of similar shape may be present just behind each spermathecal pore.

The single female pore is median (6).

Apertures of the copulatory chambers are transversely slit-like.

Genital markings are in paired or unpaired and median groups as follows.—Paired groups presetal on viii and ix, postsetal on vii and viii; on xviii three presetal markings on the right side and two on the left, one postsetal marking on the left side; on xix, four presetal markings on each side and one median, two postsetal markings on the right side, one on the left side (# 1). Paired groups presetal on viii and ix, postsetal on viii; on xviii two presetal markings on the right side, one on the left and a median group of five; on xix, two presetal markings on the right side, two on the left side and one median (# 2). One pre-and one postsetal marking on vii on each side; paired groups presetal on viii and ix and postsetal on viii; on xviii two presetal markings on the right side, four postsetal markings on the right side and one on the left side (# 3). Markings on xviii and xix, unless midventral, are just median to the male pore lines. Paired groups of markings on viii and ix are eight to ten intersetal intervals median to the spermathecal pore lines, to ten markings in a group. Presetal and postsetal median groups on vii, viii, ix, xviii and xix (# 4). Two presetal and two postsetal markings on vii in a median region, median groups presetal on viii, ix, xviii and xix, two presetal markings on xx (# 5). Presetal median groups on vii, viii, ix, xviii and xix (# 6). Markings are roughly in two transverse rows per group, seven to nine in a group.

Genital markings are tiny, more or less distinctly demarcated tubercles of circular to shortly elliptical outline, each marking with a regularly convex central portion which may be greyish translucent or opaque and a narrow marginal band which may also be translucent, central area and band separated from each other by a very slight circular groove. A minute spot just visible at centre of an occasional marking may be a pore.

Internal anatomy.—Septa 8/9-9/10 are lacking, none thickly muscular. A mid-dorsal pigmented stripe is present but is invisible externally or almost so. Internally the stripe is not as clearly visible as in other species either because of more sparse pigmentation or because of covering by translucent tissues.

A cuticular lining of the oesophagus is recognizable to or nearly to the level of the hearts of x. The inner wall of the oesophagus is provided at the mid-ventral and mid-dorsal lines with low longitudinally placed, white ridges, and elsewhere with vertically placed, slightly higher but also white ridges. The intestine begins in xv (6). The intestinal caeca are simple, margins smooth or with slight septal incisions (6). The typhlosole begins abruptly in the caecal segment (continuous with a very low blade-like ridge extending anteriorly into xvi or xvii) and is lamelliform, gradually decreasing in height posteriorly, unrecognizable behind lix (specimen of 75 segments, probably abnormally short) or lviii (specimen with 101 segments). On the inner wall of the intestine a conspicuous longitudinal ridge extends from the anterior margin of the caecal aperture forwards into xxii, the ridge forming a boundary between a dorsal and ventral series of sacculations, the dorsal sacs about half the size of the ventral.

The dorsal blood vessel (single) is continued anteriorly to the region of the suprapharyngeal ganglia. A supra-oesophageal trunk is recognizable only in x-xiii, terminating at either end with branches to hearts (of x or xiii). Extra-oesophageal trunks pass onto the ventral surface of the gut in the region of x from whence they run posteriorly parallel to the midventral line, disappearing from sight in xiii. Hearts of xi-xiii bifurcate dorsally, the larger anterior branch passing to the supra-oesophageal, the slender posterior bifurcation passing to the dorsal trunk. Hearts of x have been traced only to the supra-oesophageal. The single heart of ix is on the left side (2) or the right side (3) and opens into the dorsal trunk only. The last hearts are in xiii (6). All hearts of ix to xiii pass into the ventral vessel. Blood glands are present in v. Lymph glands are large, leaf-like paired discs, from xxiv, xxv or xxx posteriorly, usually containing clumps of brown debris. Anterior to region of xxx-xxiv the glands are small and white or unrecognizable.

Seminal vesicles are lateromesially flattened and large, the posterior vesicles dislocating 12/13 into contact with 13/14, the anterior vesicles pushing 10/11 forward into contact with the gizzard. The posterior vesicles are easily removed as usual but the anterior vesicles adhere by very delicate, transparent tissue to 10/11, 11/12, the gut, the testis sacs, and above the gut to each other. With care this tissue can be cut so that the vesicles can be removed without opening the testis sacs. The latter are unpaired and ventral (6), the anterior sac on the posterior face of 10/11 and crowding the posterior sac against the anterior face of 11/12. Both sacs are dorsal to the nerve cord. The prostates extend through xvii-xix or xx. The prostatic duct is muscular,

about five mm. long, narrowed ectally and entally, coiled around the base of the copulatory chamber on the anterior and median sides, passing dorsally on the posterior side and on top of the chamber with a tiny quirk, then penetrating into the centre of the dorsal face of the chamber. The duct is bound to the chamber by fairly strong but nearly transparent tissue. The chamber has a rounded mound-shape, a fairly thick wall, the lumen rather small and nearly filled by a slender penis that is $1\frac{1}{2}$ -2 mm. long. The minute male pore is at the tip of the penis which is slightly constricted in an annular manner, fourteen constrictions noted on one penis. The male deferent duct passes into the prostatic duct slightly below the ental end.

The spermathecal duct is longer than and sharply marked off from the ampulla, rather slender but with slight muscular sheen, nearly circular in cross section. In an ental portion next to the ampulla and much shorter than the rest of the duct the lumen is shortly elliptical in cross section. In this ental chamber the aperture into the diverticulum is at the ectal end while the opening into the other portion of the duct is at the centre of a rounded tubercle on a side wall. In a very short portion of the duct ectal to the tubercle the circular muscle layer is considerably thickened, the lumen very small and almost circular in cross section, from hence ectally the lumen fairly large, slit-like in cross section or irregular as a result of the presence of low, longitudinal ridges. Ectal to the tubercle chamber the duct is looped one or twice, the loops shortly u-shaped, the limbs of the loops in contact and bound together. The first bend of the ental loop is always on the side of the duct opposite to that joined by the diverticular stalk. The diverticulum which passes to the ectal end of the chamber of the duct is small, comprising a shortly ellipsoidal to sausage-shaped, simple seminal chamber and a slender stalk that is looped once or twice like the duct.

Genital marking glands are stalked and coelomic, stalks of postclitellar glands longer, one gland to each marking though the duct of each gland is composite, a bundle of several stalks.

Parasites.—In the coelomic cavities of each specimen there are nematodes. Numbers of cysts are in the nerve cord of each worm. Smaller cysts may be present on or in the body wall and two specimens have clusters of still a different type of cyst in the coelomic cavities.

Remarks.—The slender posterior bifurcations of the hearts of xi-xiii passing to the dorsal trunk are white or translucent and without blood, in all specimens of this as well as of other species from Kedah and Perlis. Absence of blood from these slender connections is not however to be taken as evidence for lack of a lumen as blood is also unrecognizable in the anterior bifurcations.

The position of the anterior testis sac behind septum 10/11 is anomalous but there is no confusion as to septa for the heart of ix is some distance anterior to 10/11 and the hearts of x are on the anterior face of 10/11. The anterior seminal vesicles can be removed without difficulty so as to leave 10/11 intact. There is no communication anteroposteriorly between the sacs of a side though an appearance of such communication may be produced by tearing the sac walls in removing the anterior seminal vesicles.

In the diagnosis of *annandalei* in a recent article on Siamese earthworms the external apertures of the spermathecae were referred to as secondary, on an assumption that minute primary pores are present internally. In the Perlis specimens minute, internal pores have not been found. Unless the opening on the tubercle in the entalmost portion of the duct can be regarded as a primary pore (which does not seem feasible in spite of the presence of a cuticular lining of the duct ectally) the external aperture must be regarded as primary but large.

Specimens with paired, lateral groups of genital markings cannot be distinguished otherwise from worms with the unpaired and median groups characteristic of the types, one of the Perlis specimens providing a transition between the two conditions so far as postclitellar markings are concerned.

Pheretima balingensis n.sp.

Baling, Kedah. 12/1938. 17 clitellate specimens.

External characteristics.—Length 63–120 mm. Diameter four to five mm. Pigmentation red, restricted to the dorsum, sparse or lacking behind the clitellum.

Setae begin on ii but may be partly lacking on ii and iii. Setal formulae below are from the less softened specimens.

SETAL FORMULAE

vi	vii	viii	xvii	xviii	xix	ii	iii	iv	xiii	xii	xx
36	35	39	16	11	15	2+	15+	37	50	49	58
36	32	39	15	10	15	24	26+	35	48	50	49
37	37	31	17	10	16	27	35	40	43	64	62*
32	34	33	14	12	14	14+	30	41	49	51	56
32	31	40	18	11	17	19+	31	37	56	52	54
35	36	39	14	10	16	27	30	39	54	57	60

*52/yi

The first dorsal pore is on 11/12 (5), possibly on 12/13 but with a definitely pore-like marking on 11/12 but no perforation recognizable (7).

The clitellum is dark grey, annular, extending to, nearly to or just beyond 13/14 and 16/17; intersegmental furrows, dorsal pores and setae lacking.

Spermathecal apertures are transversely placed slits on 5/6-8/9, within the pigmented region and on the dorsum but fairly widely separated.

The single female pore is median (13).

Apertures of the copulatory chambers are transversely slit-like, in the setal circle of xviii. On one worm copulatory chambers are everted.

Genital markings are always in postsetal, unpaired and median groups located as follows:—vii-viii, xvi-xviii (2), vii-viii, xvi-xix (1), vii-viii, xvii-xviii (11), vii-viii, xvii-xix (2). The markings are in two transversely placed rows per group but with occasional irregularities, the number per group varying from twelve to twenty two anterior to the clitellum and from eleven to twenty posteriorly. On one specimen the markings of xviii are in a single transverse row. Each marking comprises a tiny, greyish translucent central area with an opaque, white line of varying thickness peripherally and bounded by a very slight circular groove. External to the groove there is a marginal area which may be greyish translucent but is not sharply demarcated peripherally.

Internal anatomy.—Septa 5/6-7/8 are slightly muscular; 8/9-9/10 lacking; 10/11 and succeeding septa transparent. A brilliant red mid-dorsal stripe is recognizable externally behind the clitellum only but is visible internally into x or xi where it disappears.

The inner wall of the oesophagus in x-xiii is provided at the middorsal and midventral lines with the usual longitudinal ridges and in between slightly higher and vertical but also white ridges. The intestine begins in xv (12). Intestinal caeca are simple, the margins smooth or with slight septal constrictions (12). The typhlosole begins abruptly just in front of the caecal apertures (continuous anteriorly with a low blade-like ridge into xvi or xvii) and is lamelliform, gradually decreasing in height posteriorly but ending abruptly as follows: lviii (specimen with 79+ segments), lxi (specimen with 101 segments), lxii (specimens with 80+ and 104 segments), lxiii (specimen with 95 segments). Earth in the gut is brick-red coloured.

The dorsal blood vessel (single) is continued forwards to a point just anterior to the cerebral ganglia where it bifurcates, the branches passing lateroventrally on the pharyngeal bulb.

The trunk passes underneath the cerebral ganglia (4). The supra-oesophageal disappears from sight slightly behind the gizzard and in a posterior portion of xiv. Extra-oesophageal trunks are formed in v by the union of two fairly large vessels one of which drops nearly to the ventral parietes where it is continued anteriorly, parallel to the nerve cord, to the region of the subpharyngeal ganglia. In the region of x the trunks pass onto the ventral surface of the gut almost at the median plane, diverging in xiii, passing off onto the anterior face of 13/14 and thence ventrally to the parietes. One of the vessels has been traced along the parietes to join a subneural trunk in xvi. The ventral trunk is visible anteriorly to a region just in front of the subpharyngeal ganglia where it bifurcates, the branches passing laterally; from 4/5 anteriorly in or on a horizontal subpharyngeal mesentery. Subneural trunks are quite unrecognizable in six specimens, in one specimen visible only for a short distance, from xv into xix. Hearts of xi-xiii bifurcate dorsally, the larger anterior branch passing into the supra-oesophageal trunk, the slender and white posterior branch to the dorsal trunk. Hearts of x have been traced only to the supra-oesophageal trunk. The single heart of ix is on the right (5) or the left side (5). All hearts of ix-xiii pass into the ventral vessel. The last pair of hearts is in xiii (12). Blood glands are present in v. Paired (?) lymph glands are small and white, recognizable only in a short posterior portion of the body.

The testis sac of x is annular (12) and passes across the dorsal blood vessel, not lobed but gradually widened ventrally, on the anterior face of 10/11, hearts of x not included but adherent to the median face of the sac. The posterior testis sac appears to be cylindrical, the seminal vesicles included. Both sacs are above the nerve cord. The prostates extend through some or all of xvii-xxi. The prostatic duct is muscular, three to five mm. long, bent into u-shaped loop and bound to the anterior and median faces of the copulatory chamber close to the parietes, posteriorly passing upwards to enter the chamber at the centre of the dorsal surface. The duct is narrowed ectally and in a u-shaped quirk which is invisible until after covering tissue has been removed. The male deferent duct passes into the ental end of the prostatic duct. The copulatory chamber has a rounded mound-shape, fairly thick wall and small lumen within which is a penis about one mm. long. The minute male pore is at the ventral end of the penis which is thickened basally.

The spermathecal duct is quite definitely shorter than the ampulla, rather slender but with muscular (?) sheen, nearly circular in cross section, abruptly narrowed about midway between the ental end and the parietes. In the wider ental portion ridges are lacking although the wall is not smooth. On

the lateral wall and definitely above the ectal end of the chamber there is a tubercle of circular outline and with a regularly convex, smooth, glistening surface. At the centre of the tubercle a small round aperture opens into the narrower ectal portion of the duct. The diverticular aperture appears to be on the opposite wall. In the ectal part of the duct the lumen is small and transversely slit-like in cross section. The diverticulum is small but reaches up onto the ampulla; the simple seminal chamber ellipsoidal to sausage-shaped, the slender stalk with two short u-shaped loops, the limbs of the loops in apposition, entering the median face of the duct slightly above the ectal end of the chamber.

Genital marking glands are small, mushroom-shaped and coelomic.

Abnormality.—A trithecal specimen, 63 mm. long and ca. 3 mm. thick, has spermathecal pores on 8/9 and on 7/8-left side.

Remarks.—Around the posterior portion of the clitellum of one specimen there is an annular band of two layers, the outer layer thin, transparent and brown, the inner soft, thicker and slightly translucent. The outer layer probably is a cocoon, the inner layer albumen. The intestine in xxvi-xxii is probably sacculated as in *annandalei*, the intestinal wall of this region macerated even in the best preserved specimens.

Lymph glands when visible certainly appear to be paired as they also do in *annandalei* but it is possible that in these as well as other species two enlarged lateral lobes of an unpaired gland are alone visible, a slender median portion connecting the two lobes having disintegrated. Lymph glands apparently disintegrate very easily and unless preservation is really good may be quite unrecognizable throughout considerable portions of the body or wholly unrecognizable. The left seminal vesicle of xii is rudimentary in one specimen.

A subneural trunk is reported as lacking in species of various Oriental genera of earthworms. In view of the inability to find any trace of a subneural trunk in a number of the Baling specimens in species in which the trunk almost certainly is present, reports of absence of a subneural, especially when specimens are not in the best condition, should perhaps be accepted with some caution.

The wall of the posterior testis sac is very delicate. A definite membrane certainly connects septa 10/11 and 11/12, at least laterally and close to the parietes in the manner of a cylindrical testis sac. Between the wall of the sac and the seminal vesicles there is usually a thin, annular layer of testicular coagulum, coagulum usually present behind the vesicles nearly to the gut. The vesicles are in contact with each other above the dorsal blood vessel and adherent to each other and to the wall of the gut. On slight traction laterally the vesicles

come away from the gut disclosing only slender filaments of transparent tissue, but nothing in the way of a continuous membrane as would be expected were the sac annular.

The worms described above are uniformly distinguished from specimens referred to *annandalei* by the restriction of genital markings to the postsetal halves of segments, the annular testis sac of x located in the normal position on the anterior face of 10/11, the shortness of the spermathecal duct relative to the ampulla and the approximately equal lengths of the two portions of the duct. The spermathecae are more like those of *malayana* than of *annandalei*. Relationship to *P. pulauensis* (Beddard) 1900 is probably even closer although Beddard's species is still inadequately characterized in spite of corrections and emendations by Stephenson after study of the types. For the present *balingensis* is distinguished from *pulauensis* by a restriction of genital markings to postsetal halves of the segments.

Diagnosis.—Octothecal, spermathecal apertures widely paired, transverse slits, on the dorsum, on 5/6–8/9. Male pores minute, each at ventral end of a 1 mm. long, rather conical penis within an eversible copulatory chamber. Genital markings tiny circular areas in unpaired and median, postsetal groups of two rather irregular rows, on vii–viii, xvi–xiv. Setae: vi/30–37, vii/31–37, viii/31–40, xvii/14–17, xviii/10–12, xix/14–17, 24–27/ii, 30–35/iii, 35–41/iv, 48–56/viii, 49–64/xii, 49–62/xx. First dorsal pore on 11/12 (–12/13?). Length 63–120 mm. Diameter 4–5 mm.

Intestinal caeca simple. Testis sac of x annular, of xi cylindrical. Spermathecal duct shorter than ampulla, ental chamber about as long as rest of duct and opening ectally through a lateral papilla; diverticulum small with a slender, shortly looped stalk to median face of ental chamber of duct and simple ellipsoidal seminal chamber reaching onto ampulla. Genital marking glands stalked and coelomic.

Distribution.—Known only from the type locality, Baling, in Kedah.

Pheretima brinchangensis Stephenson.

Pheretima brinchangensis Stephenson 1932, Bull. Raffles Mus. No. 7, p. 42. (Type locality, Brinchang Road, Cameron Highlands, Pahang. Types in the British Museum.)

Pheretima brinchangensis Gates 1936, Bull. Raffles Mus. No. 12, p. 92. (Diagnosis.)

Gunong Pantl, Johore. Lowland jungle. 3/1938. 6 clitellate and 1 acitellate specimens.

Remarks.—Two worms are longer than previous specimens, nearly 100 mm.

The spermathecal pores, on all of the specimens, appear to be on viii and ix, usually close to 7/8 and 8/9, rather than on

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the intersegmental furrows. On one specimen, one pore is almost midway between the furrow and the setal circle.

The typhlosole begins abruptly in the caecal segment and is unrecognizable behind segment 1, but is low throughout. The inner wall of the oesophagus in x-xiii is ridged as usual.

The spermatzoal iridescence extends down into an-ental portion of the looped middle part of the diverticulum.

Pheretima flozellana n.sp.

Baling, Kedah. 12/1938. 1 acitellate and 31 clitellate specimens.

External characteristics.—Length 32–56 mm. Diameter two to three mm. Pigmentation red, restricted to the dorsum except on i-viii, dense anterior to the clitellum, sparse or lacking posterior to the clitellum.

Setae begin on ii. Formulae below are from less softened specimens.

SETAL FORMULAE

vi	vii	viii	xvii	xviii	xix	ii	iii	iv	viii	xii	xx
31	33	35	12	10	12	36	41	47	50	50	51
34	28	32	12	8	9	36	41	43	45	47	44*
28	20	..	12	4	8	31	38	30	..	44	40
32	34	36	12	9	8	32	42	43	..	..	46
35	30	33	14	11	8	27+	40	41	43	46	48
..	..	..	14	12	11	36	41	44	..	..	43

* This specimen is the only one on which clitellar setae were noted, 2/xvi midventrally.

The first dorsal pore is on 12/13 (1), on 12/13 but with a pore-like and possibly perforate marking on 11/12 (7).

The clitellum is dark grey, annular, extending to or nearly to 13/14 and 16/17; intersegmental furrows and dorsal pores lacking, setae usually lacking.

Spermathecal apertures are transversely placed slits on 5/6–8/9, on the dorsum but fairly widely separated dorsally. The ventral distance between the openings on one furrow about three times that between the male pores.

The single female pore is median (7).

Apertures of the copulatory chambers are transversely slit-like, in the setal circle of xviii.

Apertures of pseudo-copulatory chambers are transversely slit-like, in the setal circle of xix, in line with and of the same size and appearance as the copulatory chamber apertures (32). One specimen has an extra aperture on xvii on the right side. Another specimen has two extra apertures, on xx and xxi, on the left side.

Genital markings are paired (normally), presetal, transversely placed, slightly raised areas of shortly elliptical outline, about two intersetal intervals wide, eight to ten intersetal intervals median to the spermathecal pore lines and separated midventrally by a space equal to twelve to fourteen intersetal intervals. Each marking has a greyish translucent central area and an opaque marginal band. Markings are located as follows: vi-viii (2); vi-left side, vii-viii (1); vi-left side, vii, viii-right side (1); vi-right side, vii, viii-right side (1); vii-viii (11); vii-left side, viii (1); viii (1); no markings (14).

Internal anatomy.—Septa 8/9-9/10 are lacking; no septa are especially muscular. A light red, mid-dorsal stripe is recognizable behind the clitellum.

The inner face of the oesophagus in x-xiii is provided with the usual longitudinal and vertical ridges, all white. The intestine begins in xv (8). Intestinal caeca are simple, margins with slight septal incisions. The typhlosole begins abruptly just in front of the caecal apertures (no ridge recognizable anteriorly) and is rather high, simply lamelliform, gradually decreasing in height posteriorly, unrecognizable behind lvii (specimen with 80 segments) or lvi (specimen with 79 segments). The intestine in xxvi-xxii is sacculated as in *annandalei*. Earth in the gut is brick-red coloured.

The dorsal blood vessel (single) is continued forwards to the region of the cerebral ganglia. The supra-oesophageal trunk bifurcates posteriorly in xiii, the branches passing to the hearts, unrecognizable anterior to the hearts of x. Extra-oesophageal trunks are recognizable from 5/6 posteriorly, passing onto the ventral face of the gut close to the median plane in the region of x, disappearing from sight in xiii. Subneural trunk quite unrecognizable in all dissected specimens. The last pair of hearts is in xiii (8). The hearts of xi-xiii bifurcate dorsally, the anterior branch slender, translucent and passing to the supra-oesophageal trunk, the slenderer posterior bifurcation to the dorsal trunk. Hearts of x have been traced only to the supra-oesophageal trunk. The single heart of ix is on the right side (4) or the left side (4). All hearts of ix-xiii pass into the ventral trunk. Paired (?) lymph glands, small and white are recognizable only in the tail region. Blood glands were not

recognized but on either side of the dorsal blood vessel in v and extending from 4/5 to 5/6 there is a single (glandular?) mass (of blood glands?).

The testis sac of x is annular, widened ventrally, the hearts of x included, and usually surrounded by testicular coagulum. The posterior sac is cylindrical, the seminal vesicles of xi included, in contact above the dorsal trunk and not adherent to the gut, an annular layer of testicular coagulum, thin laterally and dorsally, separates the vesicles from the sac wall. The hearts of xi are bound to the anterior face of 11/12 and hence are not in contact with the testicular coagulum. Both sacs are above the nerve cord. The prostatic duct is muscular, 2-2½ mm. long, passing mesially from the gland in a posterior portion of xviii, turning anteriorly, then laterally and finally passing into the centre of the dorsal face of the copulatory chamber within the wall of which it is gradually narrowed almost to a thread, the C or J-shaped loop bound to the chamber but usually not close to parietes. The vas deferens passes into the ental end of the prostatic duct. The copulatory chamber has a rounded mound-shape, a fairly thick wall and a rather small lumen. On the roof of the chamber is a conical penis less than one half mm. long, the male pore at the ventral tip. The penis may have two or three slight annular constrictions. The prostatic duct can be pulled completely out from the penis with the minute male pore on the end of the narrowed portion.

Pseudocopulatory chambers of xix (or elsewhere when present) have a very thin and transparent wall above the parietes and reach only slightly into the coelomic cavity. On the roof of the chamber is a circular marking the margin clearly demarcated but scarcely raised enough to be considered disc-like, folded so that the anterior and posterior halves are almost if not actually in contact with each other. The roof of the copulatory chamber is thick and to it pass several (probably nearly 20), rather long stalks in a composite column the width of which is about equal to the width of the genital marking in the chamber. At the ental end of the column of stalks is a thin layer of glandular material. The whole structure, chamber, stalks and gland is flattened out and bound to the parietes, extending often into xx or even xxi. Each extra aperture on xvii, xx or xxi opens into a characteristic chamber but with gland slightly smaller and bent over to parietes mesially or laterally rather than posteriorly.

The spermathecal duct is shorter than the ampulla, rather slender but with muscular sheen, nearly circular in cross section, abruptly narrowed just prior to entrance into the parietes. In the wider ental portion the lumen is fairly large and transversely elliptical in cross section. On the lateral wall close to the ectal

end there is a tubercle of smooth, regularly convex surface and circular outline. At the centre of the tubercle is a minute opening into the ectal portion of the duct. For a very short distance ectally the lumen is small but within the parietes is widened and transversely slit-like in section. The diverticulum reaches up onto the ental half of the ampulla, occasionally reaching nearly to the ental margin and comprises a sausage-shaped, simple seminal chamber nearly filled with a mass of iridescent spermatozoa and a slender stalk which passes to the median face of the duct close to the parietes but into the thicker ental portion. The stalk is slightly sinuous, occasionally with one or two open loops.

Genital marking glands are stalked and coelomic, the ducts composite, glands and stalks flattened out against the parietes.

Parasites.—In the coelomic cavities of three specimens there are numerous small gregarine cysts.

Remarks.—Some of the specimens are in such poor condition, that they fell apart during examination of the external structures. As a result certain external characteristics such as the location of the first dorsal pore, etc., were noted only on the better material.

The dorsal trunk certainly appears to be within (i.e., to pass through) the anterior testis sac, with coagulum in contact with the dorsal and lateral surfaces but it was not possible to determine if the vessel was adherent to the floor of the sac or whether the trunk is really outside of the sac and merely bulging the floor upwards.

P. florellana appears to be close to *P. bipora* (Beddard) 1900 from which it is distinguished by restriction of the preclitellar genital markings to presetal halves of the segments, the smaller pseudocopulatory chambers, the location of the genital marking directly on the roof of the pseudocopulatory chamber rather than at the end of an elongate protuberance into the lumen of the chamber, the shorter spermathecal duct and possibly by a more ectal diverticular junction.

Diagnosis.—Octothecal; spermathecal apertures widely paired, transverse slits, on the dorsum, on 5/6–8/9. Male pores minute, each at ventral end of a small, conical penis less than $\frac{1}{2}$ mm. long located on the roof of a copulatory chamber. Apertures of pseudocopulatory chambers in setal circle of xix, in line with and like male apertures; a large circular marking folded transversely, on roof of each chamber. Genital markings (often lacking) paired, slightly raised areas of transversely elliptical outline, presetal of vi–viii. Setae: vi/28–35, vii/28–34, viii/32–36, xvii/12–14, xviii/4–12, xix/8–12, 31–36/ii, 38–42/iii, 39–47/iv, 43–50/viii, 44–50/xii, 43–51/xx. First dorsal pore on 11/12–12/13. Length 32–56 mm. Diameter 2–3 mm.

Intestinal caeca simple. Testis sac of x annular, of xi cylindrical. Spermathecal duct shorter than ampulla, ental chamber longer (?) than rest of duct and opening ectally through a lateral papilla; diverticulum with slender stalk to median face of ental chamber of duct close to parietes and simple, sausage-shaped ellipsoidal seminal chamber reaching well up onto ental half of ampulla. Genital marking glands stalked and coelomic.

Distribution.—Known only from the type locality, Baling, in Kedah.

Pheretima flustrella n.sp.

Baling, Kedah. 12/1938. 3 clitellate specimens.

External characteristics.—Length 25–38 mm. Diameter one and a half to three mm. Pigmentation red, restricted to the dorsum, sparse behind the clitellum.

Setae: xvii/10, xviii/7, xix/11, 3/xv, 9/xvi; xvii/11, xviii/7, xix/11, 8/xv, 10/xvi; 12–13 between spermathecal pore lines on v, 9–11 on viii.

The first dorsal pore is probably on 11/12 (3) but on two of the specimens perforations are not definitely recognizable on the marking at that furrow.

The clitellum is dark grey, annular, extending nearly to 13/14 and 16/17; intersegmental furrows and dorsal pores lacking, setae present ventrally on xv and xvi.

Decithecal; spermathecal pores minute and superficial, transversely placed slits, five pairs, on 4/5–8/9. Segmental margins close to the spermathecal pores may be slightly whitened.

Male pores are minute and superficial, each pore at or near the centre of a slightly raised, sharply demarcated tubercle of circular to shortly elliptical (and transversely placed) outline.

No genital markings.

Internal anatomy.—Septa 8/9–9/10 are lacking; all septa membranous. The mid-dorsal stripe is of a brilliant red and recognizable internally through the clitellar segments and into x.

The inner wall of the oesophagus in x–xiii is provided with the usual ridges, all ridges white, the vertical ridges rather high relative to the size of the animal. The intestine begins in xv (3). The intestinal caeca are short, simple, bent upwards in xxvi. The typhlosole begins abruptly in the caecal segment but is so low that it might almost be considered rudimentary. Soil in the gut is brick-red coloured.

The dorsal blood vessel (single) is continued anteriorly onto the pharyngeal bulb. The supra-oesophageal bifurcates posteriorly in xiii, each branch passing to a heart. Extra-oesophageal trunks are recognizable from vi posteriorly, in the region of x passing onto the ventral surface of the gut close to the median plane, disappearing from sight in xiii. Subneural trunk unrecognizable. Hearts of x not found. The single heart of ix is on the right or the left side. Last hearts in xiii (3). All hearts of ix, xi-xiii pass into the ventral trunk. Paired lymph glands are small and white, recognizable only in a tail portion. Blood glands were not found but on either side of the dorsal trunk in v and vi there is a fairly large, flattened mass of (glandular?) tissue which appears to be a posterior extension from the pharyngeal bulb.

Nephridia on the anterior faces of 5/6 and 6/7 are relatively large. On the ventral parietes in vii-ix between the spermathecae are small whitish structures which look somewhat like genital marking glands but in absence of genital markings presumably are enlarged parietal micronephridia.

The testis sacs of x and xi are horseshoe-shaped, the seminal vesicles of xi included within the posterior sac and imbedded in testicular coagulum. Prostates extend through some or all of segments xv-xxvi. The prostatic duct is $1\frac{1}{4}$ -2 mm. long, bent into a U-shaped loop, the ectal limb slightly thickened. The duct passes into the centre of an opaque white patch in the nearly transparent body wall. Entally the prostatic duct divides into two short branches, the vas deferens passing into the anterior branch.

The spermathecal duct is shorter, than and clearly marked off from the ampulla, with muscular sheen, circular or nearly so in transverse section, slightly widened in the region of the diverticular junction, abruptly narrowed just prior to entrance into the parietes. In the wider ental portion the lumen is large and shortly elliptical in cross section, ectal to the diverticular junction very narrow, lined with cuticle, slit-like in cross section. The diverticulum which is longer than the duct, reaches up onto the ectal half of the ampulla and comprises a short, slender, nearly straight stalk passing to the median face of the duct near the parietes and an ental flattened portion of elliptical outline. At the ental end of the disc a spot of iridescence is visible, the remainder of the disc opaque or slightly translucent. On clearing, two portions are recognizable in the disc, an ental, almost spheroidal simple seminal chamber nearly filled by a ball of spermatozoa, the remainder of the disc composed of coils or loops of the diverticular stalk closely bound together. Although

the seminal chamber of each spermatheca contains a ball of spermatozoa the lumen of the coiled portion of the stalk is always empty.

Remarks.—Each specimen is so softened that setae cannot be counted. Female pores are unrecognizable (possibly paired?). In view of the very poor condition of the types characterization of the testis sacs requires confirmation from better material. As a result of the poor condition the specimens will never be of much use as types but the type locality is easily accessible.

P. flustrella appears to be close to *P. tertiodamae* Michaelsen 1934 (from the island of Pulo Dama in the Gulf of Siam) from which it can be distinguished at present only by the presence of an extra pair of spermathecae opening to the exterior on 4/5. However neither species is satisfactorily characterized. Michaelsen's figure (fig. 25) of a cleared duct and diverticulum shows characteristics similar to but not identical with those of spermathecae of *flustrella*.

One decithecal species, *P. bicincta* E. Perrier 1875, has been recorded from Penang but does not appear to be closely related to *flustrella*.

Diagnosis.—Decithecal, spermathecal pores minute and superficial, five pairs, on 4/5–8/9. Male pores minute and superficial, each pore at the centre of a slightly raised tubercle of circular to shortly elliptical outline. First dorsal pore on 11/12. Setae: v/12–13, viii/9–11, xvii/10–11, xviii/7, xix/11, 3–8/xv, 9–10/xvi. Length 25–38 mm. Diameter $1\frac{1}{2}$ –3 mm.

Intestinal caeca simple. Testis sacs horseshoe-shaped, seminal vesicles of xi included. Spermathecal duct shorter than the ampulla, slightly widened in region of diverticular junction, abruptly narrowed just prior to entrance into the parietes, with large lumen entally; diverticulum longer than duct, with simple spheroidal seminal chamber and a slender stalk mostly twisted into a flattened coiled mass, into median face of duct near parietes.

Distribution.—Known only from the type locality, Baling in Kedah.

Pheretima foveola n.sp.

Kaki Bukit, Perlis. 12/1938. 27 clitellate specimens.

External characteristics.—Length 42–73 mm. Diameter two to four mm. Pigmentation red, restricted to the dorsum posterior to the clitellum, dense anterior to clitellum, usually sparse or lacking behind the clitellum, occasionally dense to the hind end.

SETAL FORMULAE

vi	vii	viii	xvii	xviii	xix	ii	iii	iv	viii	xii	xx
21	20	19	13	11	13	23	27	31	34	40	39
21	22	20	13	9	13	10+	23	26	34	35	38
23	24	21	15	11	14	25	26	36	37	38	42
22	21	23	14	12	14	25	31	36	43	43	48
19	23	23	13	9	11	12+	31	33	42	40	44
18	21	19	15	10	14	17+	21+	30	33	40	41
21	19	21	14	11	13	25	28	29	38	39	42

The first dorsal pore is on 12/13 (9) or 13/14 (1).

The clitellum is dark grey, annular, extending to or slightly beyond 13/14 and 16/17; intersegmental furrows, dorsal pores and setae lacking.

Spermathecal apertures are transversely placed slits on 5/6-8/9, about $\frac{1}{2}$ C apart. Apertures may have a crescentic appearance and the margins are usually slightly whitened.

The single female pore is median (10).

Apertures of the copulatory chambers are transversely slit-like, in the setal circle of xviii. Copulatory chambers are completely everted on one specimen.

Genital markings are widely paired, small tubercles, one to two intersetal intervals wide, slightly protuberant, usually of circular outline, occasionally very shortly elliptical and transversely placed. Each marking has a large, circular, central area greyish translucent in part but becoming opaque towards the periphery, circumscribed by a slight groove or the groove may be unrecognizable and replaced by a narrow band of greyish translucence. The marginal band is opaque, narrow, and though clearly demarcated from the central area is not sharply marked off peripherally. Markings are always presetal, paired except as noted below, on the postclitellar segments widely and just median to the male pore lines, the preclitellar pairing variable, markings separated midventrally by spaces equal to 2, 4, 6, 8 or even 13 intersetal intervals. Postclitellar markings are located as follows: xvii-xix (3); xviii-xix (22), xviii-right side, xix (1); xviii (1). Preclitellar markings are located as follows: vi-viii (1); vi-left side, vii-viii (1); vi-right side, vii-viii (1); vii-viii (12); vii-left side, viii (2); vii-right side, viii (2); viii

(4), one of the left markings doubled on one specimen; vii-viii, ix-left side (1); vii, a transverse row of 12 on viii, one on ix-right side close to the median line (1); no preclitellar markings (1).

Internal anatomy.—Septa 8/9-9/10 are lacking; no septa especially muscular. The mid-dorsal stripe is recognizable from xvii posteriorly, occasionally faintly visible through the clitellar segments or even for a short distance anteriorly, and is a brilliant red. A similar pigmentation characterizes the muscle bands passing from the pharyngeal bulb to the parietes, and the lateral and dorsal portions of the pharyngeal bulb the pigmentation extending deeply into the bulb, lacking only in a layer next to the lumen. Individual blood glands in v are outlined by flecks of the same pigment.

The inner wall of the oesophagus in x-xiii is provided with the usual ridges all of which are white. The intestine begins in xv (8). Intestinal caeca are simple, the margins with slight septal incisions. The typhlosole begins abruptly just in front of the caecal apertures and is fairly high, simply lamelliform, continuous anteriorly with a low but blade-like ridge extending into xv, terminating rather abruptly and without marked decrease in height as shown below. There is for some distance posteriorly a mid-dorsal ridging that may be considered a posterior portion of the typhlosole or perhaps better as a post typhlosole. This is low, interrupted, and with pairs of thinner, low ridges passing off diagonally at regular or fairly regular intervals. The intestine is sacculated in xxvi-xxii as in *annandalei*. Earth in the gut is usually black though fine red particles are visible.

Typhlosole ends in Segment	Post-typhlosole ends in Segment	Number of Segments
38	58	82
39	53	78
39	53	78
39	54	77
39	55	82
40	55	81
41	56	79

The dorsal blood vessel (single) is continued anteriorly and underneath the cerebral ganglia (4), bifurcating in front of the ganglia, the branches passing lateroventrally on the pharyngeal bulb. The supraoesophageal trunk disappears from sight in xiv and anteriorly bifurcates, the branches passing to the hearts of x. The extra-oesophageal trunks are formed just in front of 5/6 by the union of three fairly large vessels of approximately

equal size, one from the anterior face of 5-6, one from the lateral face of the pharyngeal bulb and one which is close to the ventral parietes and parallel to the nerve cord. The trunks pass onto the ventral surface of the gut in the region of x close to the median plane and gradually diverge in xiii, passing off onto the anterior face of 13/14, usually disappearing from sight before reaching the parietes. In one specimen the vessels have been traced to a subneural in the region of xv-xvi. The ventral trunk bifurcates at the anterior margin of the subpharyngeal ganglia, the branches passing laterally on the circumpharyngeal nervous commissures. A subneural trunk is quite unrecognizable except in one worm and here only for a very short distance through four segments. Hearts of xi-xiii bifurcate dorsally, the anterior branch passing to the supra-oesophageal, the slender posterior branch to the dorsal trunk. Hearts of x have been traced only to the supra-oesophageal. The single heart of ix is on the left side (2) or the right side (5). Last hearts in xiii (8). All hearts of ix-xiii pass into the ventral trunk. Blood glands are present in v. Lymph glands are usually large, filled with brownish debris, occasionally recognizable as far forwards as xxvii, apparently paired though a slender and macerated transverse strand above the dorsal trunk connecting the two lobes is rather doubtfully recognizable in an occasional segment.

The testis sac of x is annular, lobed, two lateral and two ventral lobes usually recognizable, occasionally one or two dorsal lobes marked off. The lateral lobes may extend anteriorly nearly to the front margin of the gizzard while in the worm with a row of genital markings on-viii the ventral lobes reach through 7/8 into contact with 6/7. The sac passes over the dorsal trunk, the floor apparently bulged upwards by the trunk, the hearts of x included at least in part and imbedded in the testicular coagulum. The sac of xi appears to be cylindrical, a continuous but thin sheath of coagulum between the seminal vesicles and the wall, further coagulum between the gut and the seminal vesicles of xi which reach upwards into contact with the dorsal trunk or to contact with each other above the trunk. Hearts of xi are bound by transparent tissue to 11/12 and hence are not in contact with the testicular coagulum. Both sacs are above the nerve cord but the posterior sac is at least in part adherent to the cord. Prostates extend through xvii-xx. The prostatic duct is muscular, $1\frac{1}{2}$ -2 mm. long, in a J-shaped loop, the long limb passing mesially in an anterior portion of xviii and then curved laterally to pass into the centre of the dorsal face of the copulatory chamber. The vas deferens passes into ental end of the prostatic duct. The copulatory chamber is small, concealed by a thick "fur" of parietal micronephridia and beneath the

prostatic duct to which it is bound. Within the chamber is a rather conical penis about one half mm. long or a trifle more, quite slender towards the tip which bears the minute male pore.

Spermathecae are small. The spermathecal duct is shorter than the ampulla, with muscular sheen, nearly circular in cross section, the parietal and coelomic portions of about equal length, very slightly thickened just at the region of the diverticular junction but without abrupt narrowing. Entally the lumen is transversely elliptical in cross section and ectally is transversely slit-like. In a very short parietal portion of the duct the lumen is circular in section and very small, opening into the wider lumen entally through a circular pore at the centre of a tubercle of circular outline, smooth and regularly convex surface. So far as can be determined this tubercle is at the ectal end of the chamber rather than on the lateral wall. The diverticulum passes to the median face of the duct close to the parietes, reaches onto the ental half of the ampulla, occasionally even to the ental margin, and comprises an elongately ellipsoidal, simple seminal chamber and a slender stalk that may be sinuous, loosely or tightly looped *i.e.*, with limbs of loops in contact.

Genital marking glands are shortly stalked and coelomic, glands and stalks composite, the composite character of the glands clearly indicated by an irregular lobing, and especially in the postclitellar segments by a separation of the lobes though stalks remain loosely bound together.

Parasites.—In nerve cord of each specimen (8) there are numerous cysts. These may be so closely crowded that nervous tissue is practically non-existent for short intervals. In the coelomic cavities of four specimens there are nematodes. Gregarine cysts are present in the coelomic cavities of one specimen.

Remarks.—*P. jovella* is close to *P. malayana* (Beddard) 1900, the two species mainly distinguished from each other much as are *pulauensis* and *balingensis*, by restriction of genital markings to presetal or postsetal halves of the segments.

Diagnosis.—Octothecal; spermathecal apertures transverse slits on 5/6–8/9, *ca.* $\frac{1}{2}$ C apart. Male pores minute, each at ventral end of rather conical, $\frac{1}{2}$ + mm. long penis on roof of small, eversible copulatory chamber. Genital markings small, paired tubercles, just median to male pore lines posterior to the clitellum, closely to widely paired anteriorly, presetal on vi–ix and xvii–xix. Setae; vi/18–23, vii/19–24, viii/19–23, xvii/13–15, xviii/9–12, xix/11–14, 23–25/ii, 23–31/iii, 26–36/iv, 33–43/viii, 35–40/xii, 38–48/xx. First dorsal pore on 12/13. Length 42–73 mm. Diameter 2–4 mm.

Intestinal caeca simple. Testis sac of x annular, of xi cylindrical. Spermathecal duct shorter than ampulla, coelomic

portion (ental chamber) about as long as parietal portion (opening ectally through a transversely placed papilla?); diverticulum with slender stalk to median face of duct close to parietes and a simple, ellipsoidal seminal chamber reaching well onto ental half of ampulla. Genital marking glands stalked and coelomic.

Distribution.—Known only from the type locality, Kaki Bukit, in Perlis.

Pheretima indica (Horst).

Megascolex indicus Horst 1883 (part), Notes Leyden Mus. V, p. 186. (Excluding specimens without copulatory chambers. Type locality unknown. Types in the Leyden Museum?)

Pheretima indica Gates 1935, Bull. Raffles Mus. X, p. 83. Synonymy and diagnosis.)

Lowland jungle. Gunong Panti, Johore. 3/1938. 5 acitellate and 8 clitellate specimens.

Baling, Kedah. 12/1938. 10 clitellate specimens.

Internal anatomy.—The mid-dorsal stripe is clearly visible from xvii posteriorly but is without pigment.

The inner wall of the oesophagus in x-xiii is provided with the usual ridges, all white. The typhlosole begins just in front of the caecal apertures and is fairly high and simply lamelliform through xxxv, low from xxxvi posteriorly though still in part at least lamelliform, unrecognizable behind lxii (specimen with 92 segments) or lxxv (specimen with 108 segments). The gut is filled with a brick-red coloured soil.

The dorsal blood vessel (single) is continued anteriorly underneath the cerebral ganglia (4), bifurcating in front of the ganglia, the branches passing lateroventrally on the pharyngeal bulb. The supra-oesophageal disappears from sight in xiv and is continued anteriorly nearly to the gizzard. The extra-oesophageals are formed in v by the union of two fairly large vessels, one from the lateral face of the pharyngeal bulb, the other from the dorsal face of the subpharyngeal mesentery slightly lateral to the ventral vessel. The trunks pass onto the ventral face of the gut close to the median plane in the region of x, gradually diverging from xi posteriorly, passing off the gut in xiv to and then through septum 14/15, and to the parietes in xv. In most of the specimens the posterior portion of the trunk in xiv and xv is unrecognizable and the continuation on the parietes in xv-xvi to the subneural is visible only in one specimen. The ventral trunk is on the horizontal subpharyngeal mesentery from 4/5 anteriorly, bifurcating at the anterior margin of the subpharyngeal ganglia, the branches passing laterally on the circumpharyngeal nervous commissures. A subneural trunk is quite unrecognizable in all but one of the

specimens and in the exceptional worm is visible only in xiv-xvi. The hearts of xi-xiii bifurcate dorsally, the anterior branch passing to the supra-oesophageal, the slender posterior branch to the dorsal trunk. Bound to the anterior face of 10/11 and connecting the ventral and supra-oesophageal trunks on each side of each of the specimens is a slender whitish cord of the same size and appearance as certain minor vessels not mentioned above. In three specimens a short dorsal portion of each of these structures is widened to about the size of a heart, and in one of these worms there is on each side a slender cord from the widened portion to the dorsal trunk. If actually tubular these commissural vessels can scarcely be hearts but having the exact morphological relationships of the hearts of x are to be regarded as vestigial hearts perhaps still functional as non-contractile vessels. The single heart of ix is on the left side (3) or right side (6). Lymph glands are small, apparently paired, recognizable only posteriorly. Blood glands are present in v.

Some or all of the spermathecae of each dissected specimen have secondary seminal chambers on the diverticula.

Pheretima malayana (Beddard).

Amyntas malayanus Beddard 1900, Proc. Zool. Soc. London, 1900, p. 893. (Type locality Aring, Kelantan. Types in the British Museum.)

Pheretima malayana Stephenson 1932, Ann. Mag. Nat. Hist. (10), IX, p. 220. (After examination of types.)

Baling, Kedah. 12/1938. 3 clitellate specimens.

External characteristics.—Length 93–110 mm., a specimen 72 mm. long probably abnormally short. Diameter 4 mm. Pigmentation red, restricted to the dorsum, sparse.

Setae begin on ii, but on that segment most of the chaetae have been lost. Formulae: vi/18, vii/19, viii/20, xvii/12, xviii/11, xix/14, 3/ii, 28/iii, 46/viii, 48/xii, 51/xx; vi/22, vii/22, viii/20, xvii/10, xviii/9, xix/10, 4/ii, 20/iii.

The first dorsal pore is probably on 11/12 although perforations are not definitely recognizable at that furrow in two of the specimens.

The clitellum is dark grey, annular, extending to or nearly to 13/14 and 16/17; intersegmental furrows, dorsal pores and setae lacking.

The spermathecal apertures are transversely placed slits on 5/6–8/9 at the ventral margins of the pigmented region, ca. $\frac{1}{2}$ C apart.

The single female pore is median (1).

Apertures of the copulatory chambers are transversely placed slits in the setal circles. On two specimens the copulatory chambers are partially everted so that penes are visible externally.

Genital markings are widely paired, small tubercles, one to two intersetal intervals wide, rather conspicuously raised, sharply demarcated, of circular to shortly elliptical outline and in the latter case transversely placed. Each marking has a circular, greyish translucent central area and a wide, opaque, white marginal band, central area and marginal band separated by a slight but definite circular groove, a slight opacity of the central area just internal to the groove. If the stalk of the associated gland is carefully dissected out from the parietes internally the translucent central area comes away on the ectal end of the stalk leaving the marginal band intact. Postclitellar markings are slightly median to the male pore lines and are on the anterior portion of the postsetal half of the segment with the anterior margin of the marking just at the setal circle. Preclitellar markings are pre- and postsetal, slightly nearer to setal circles than to intersegmental furrows, six to eight intersetal intervals median to the spermathecal pore lines and separated midventrally by a space equal to four to seven intersetal intervals. Markings are located as follows:—vi-ix, right presetals of vii-viii doubled, xvii-xxiii and left side of xxiv, right marking of xviii doubled (# 1); vi-ix, the right presetal of vi lacking, the right postsetal of vi doubled, xvii-xx and the right side of xxi (# 2); vi-ix, xvii-xxii (# 3).

Internal anatomy.—Septum 5/6 is slightly muscular, 6/7-7/8 muscular; 8/9-9/10 lacking; 10/11 and succeeding septa transparent. On the coelomic face of the parietes at the mid-dorsal line in the postclitellar portion of the body is a dark red, slightly raised, longitudinal stripe. It is this stripe that is visible externally through the body wall and often mistaken for the dorsal blood vessel.

On the inner wall of the oesophagus in x-xiii at the mid-dorsal and midventral lines there are low, longitudinally placed, white ridges. Between these ridges there are slightly higher, closely crowded, vertically placed, white ridges. The intestine begins in xv (3). Intestinal caeca are simple, the margins smooth or with slight septal incisions. The typhlosole begins abruptly just in front of the caecal apertures (no ridge anteriorly) and is high and lamelliform, gradually decreasing in height posteriorly, unrecognizable behind lix (specimen with 75 segments, probably abnormally short) or lxxv (specimen with 98 segments). Soil in the gut is brick-red coloured.

The dorsal blood vessel (single) is continued anteriorly to the cerebral ganglia. The supra-oesophageal trunk bifurcates in x and xiii, the branches at both ends passing to hearts. Extra-oesophageal trunks are formed just in front of 5/6 by the union of three vessels one of which drops down nearly to the ventral

parietes where it can be traced anteriorly nearly to the level of the subpharyngeal ganglia. In the region of x the trunks pass onto the ventral face of the gut and so close to the median plane as to come into contact. In xiii the trunks gradually diverge, posteriorly passing off the gut and then ventrally on the anterior face of 13/14, unrecognizable after reaching the parietes. The ventral trunk is visible nearly to the level of the subpharyngeal ganglia. A subneural trunk if present is unrecognizable (2). Hearts of xi-xiii bifurcate dorsally, the larger anterior branch passing to the supra-oesophageal trunk, the slender posterior branch to the dorsal trunk. In one specimen a slender translucent band of tissue connects each heart of x with the dorsal trunk in the manner of the posterior bifurcation of hearts in xi-xiii. Such a band probably would have been overlooked but for a sharp outlining by numerous flecks of black pigment. The single heart of ix is on the right or the left side. Hearts of ix-xiii all open into the ventral trunk. Blood glands are present in v. Unpaired lymph glands placed transversely across the dorsal blood vessel in the posterior portions of the segments are recognizable only towards the hind end.

The testis sac of x is annular and passes across the dorsal blood vessel, the hearts of x included, irregularly lobed or bulged, the two largest lobes ventrally. The posterior testis sac appears to be cylindrical, the seminal vesicles included and imbedded in the testicular coagulum.

The anterior testis sac is above the nerve cord but the cord appears to be within the posterior sac. Prostates extend through some or all of xvii-xxiv. The prostatic duct is about five mm. long, muscular, narrowed entally and ectally, the narrowed ectal portion within the roof of the copulatory chamber. The duct is bent into a U-shaped loop and passes into the centre of the dorsal face of the copulatory chamber. The male deferent duct passes into the ental end of the prostatic duct. The copulatory chamber has a rounded mound-shape, fairly thick wall and small lumen nearly filled by the penis which is rather conical one half to one mm. long and with the minute male pore at its tip.

The spermathecal duct is shorter than the ampulla and may be less than half the length of the ampulla but is slightly longer than is first recognizable for the ampulla is bound down around the duct so that the ental end of the duct is protuberant into the ampullary cavity like a small papilla. The duct is rather slender but with a muscular (?) sheen, nearly circular in cross section, abruptly narrowed just prior to entrance into the parietes. In the wider ental portion the lumen is irregular due to the presence of several longitudinal ridges on the wall, one of the ridges quite

noticeably larger than the others. On the lateral wall and definitely above the ectal end of the chamber there is a tubercle of circular outline and with a regularly convex, smooth, glistening surface. At the centre of the tubercle a small, round aperture opens into the narrower ectal portion of the duct. In the short ectal part of the duct the lumen is narrow and transversely slit-like in section. The diverticulum is small just reaching up into contact with the ectal margin of the spermathecal ampulla, the simple seminal chamber shortly ellipsoidal to sausage-shaped, the stalk slender, with one or two U-shaped loops, the limbs of the loops in apposition, passing into the median face of the duct in region of the ectal end of the widened portion.

Genital marking glands are flattened out against, and may be bound to the parietes but are not sessile, the ducts fairly long, especially of the postcelitellar glands and composite, of at least three stalks.

Remarks.—Two of the specimens are in such poor condition that accurate setal counts dorsally are impossible.

The dark colouration mentioned by Stephenson is probably an artefact.

The wall of the posterior testis sac is very delicate and all that has been found is a membrane just internal to the parietes connecting 10/11 and 11/12 in the manner of a cylindrical testis sac. An annular testis sac markedly distended, as would be the case in these specimens, might be adherent to the septa in such a way as to present the appearance of a cylindrical sac, but a median membrane or wall near the gut should be recognizable. In absence of evidence to the contrary the sac is regarded for the present as cylindrical. There is no communication between the two testis sacs. Stephenson, who like Michaelsen usually speaks of "paired" sacs regardless of a paired or unpaired condition, says that "the sacs of the same side communicate", a characterization that has also been made of other species and by Michaelsen as well. In careful dissections such a communication is never found. The only explanation that seems possible for such a statement, so far as dissections are concerned, is that a communication has been made between the two sacs in the course of dissection, possibly by removal of a seminal vesicle. (Each seminal vesicle of xi, otherwise a closed sac, opens into the testis sac of x through a tiny aperture in septum 10/11, the vesicle adherent to the septum around the aperture. Removal of a seminal vesicle from the posterior face of 10/11 in *malayana* leaves an aperture through which the two sacs are in communication with each other but this communication is an artefact).

The spermathecae are similar to those of *balingensis*, the only important difference between the two is in the length of the ectal portion of the duct relative to the wider ental portion; in *balingensis* the two portions of the duct of about the same length, in *malayana* the ectal portion shorter.

P. malayana has been known hitherto only from the types but in spite of corrections and emendations of the original account by Stephenson after examination of types, testis sacs, male genital terminalia, genital marking glands and spermathecae, (all of which are structures of major taxonomic importance in the genus *Pheretima*) are still inadequately characterized or wholly omitted from consideration. In these circumstances any identification as *malayana*, even if worms are from the type locality, may be incorrect. The only evidence against identification of the Baling specimens as *malayana* is a more anterior location on the segment of the postclitellar genital markings, presence of preclitellar markings and of copulatory chambers. At present very little weight can be attached to this evidence. Genital markings are often quite variable as to number and location and may even have been overlooked in part on the types. Stephenson did not say that copulatory chambers are lacking but merely that none are visible, i.e., recognized. Beddard's figure showing a transversely slit-like aperture on xviii certainly does indicate that the male pore is within some sort of an invagination which might well be a copulatory chamber as in the Baling worms. In the softened specimen from Baling copulatory chambers probably would have been overlooked if the prostatic duct had not been traced through body wall.

Diagnosis.—Octothecal; spermathecal apertures widely paired, transverse slits, on 5/6–8/9. Male pores minute, each at ventral end of rather conical, $\frac{1}{2}$ –1 mm. long penis on roof of an eversible copulatory chamber. Genital markings small, paired tubercles, just median to male pore lines posterior to the clitellum, more closely paired anteriorly; presetal and postsetal on vi–ix, postsetal on xvii–xviii. Setae; vi/18–22, vii/19–22, viii/20, xvii/10–12, xviii/9–11, xix/10–14, 3–4/ii, 20–28/iii, 46/viii, 48/xii, 51/xx. First dorsal pore on 11/12–12/13. Length 93–110 mm. Diameter 4 mm.

Intestinal caeca simple. Testis sac of x annular, of xi cylindrical. Spermathecal duct shorter than ampulla, ental chamber longer than rest of duct and opening ectally through a lateral papilla; diverticulum small, stalk slender, looped, to ectal end of ental chamber of duct, seminal chamber simple, ellipsoidal and just reaching up to ectal margin of ampulla. Genital marking glands stalked and coelomic.

Distribution.—Kelantan and Kedah.

Pheretima mamillana Gates.

Pheretima mamillana Gates 1931, Rec. Indian Mus. XXXIII, p. 400.
(Type locality Ye, Anherst district, Burma. Types in author's collection.)

Pheretima mamillana Gates 1936, Rec. Indian Mus. XXXVIII, p. 430.
(Diagnosis.)

Baling, Kedah. 12/1938. 7 clitellate specimens.

Kaki Bukit, Perlis. 12/1938. 7 clitellate specimens.

External characteristics.—Length 52–85 mm. Diameter $2\frac{1}{2}$ –4 mm. Pigmentation red, restricted to the dorsum, dense anterior to the clitellum, sparse, lacking or dense posterior to the clitellum.

SETAL FORMULAE

vii	viii	xvii	xviii	xix	ii	iii	iv	viii	xii	xx	Locality
20	21	16	9	18	25	28	32	42	49	50	Baling
20	20	18	9	18	20	27	20	39	38+	48	
19	20	12	8	15	20	28	28	34	40	44	
15	15	12	9	14	19	21	24	31	30	40	*
20	21	15	6	10	19	26	31	40	40	46	Kaki Bukit
17	18	15	8	14	17+	26	20	36	41	45	
20	19	15	9	14	25	30	33	40	40	44	

* Specimen with cysts and gregarines.

The first dorsal pore is on 12/13 (11).

The clitellum is dark grey and extends to, nearly to or just beyond 13/14 and 16/17; intersegmental furrows, dorsal pores and setae lacking.

The single female pore is median (11).

No genital markings externally.

Internal anatomy.—A mid-dorsal stripe is present but may or may not be pigmented. The earth in the gut is light yellow coloured (2 specimens from Baling), brick-red coloured (five specimens each from Baling and Kaki Bukit) or black (2 specimens from Kaki Bukit). A glandular collar on the oesophagus just behind the gizzard is fairly well developed in one worm from Kaki Bukit and in another worm is represented by a broken ring of tiny spheroids, unrecognizable in other specimens, perhaps as a result of maceration. The typhlosole begins

abruptly just in front of the caecal apertures and is fairly high and lamelliform, gradually decreasing in height posteriorly, unrecognizable behind lxxx (worm with 117 + segments).

A subneural trunk is recognizable only in one worm and only in the region of xv-xvii. Lymph glands, apparently paired, are small and recognizable only in the tail segments. Blood glands are present in v.

Testis sacs are paired and ventral in each of the Kaki Bukit specimens and one from Baling, unpaired and ventral in the other Baling worms. The vas deferens passes into the ental end of the muscular portion of the prostatic duct. Two or three stalked and composite glands are present on each copulatory chamber. One genital marking is always present on the median wall of each chamber, a second tubercle usually present on the median wall, neither tubercle on a column as in Burmese worms. On the roof of the chamber anterior to and actually indenting the margin of the male porophore there is another tubercle in each of the Baling specimens. Two definitely slit-like apertures may be visible on the dorsal tubercle. When present in the Kaki Bukit specimens the dorsal tubercle is as large as the male porophore. In the Kaki Bukit specimens male porophores are quite small, in the Baling worms more like the porophores of Burmese specimens.

The spermathecal duct is shorter than the ampulla, circular in cross section, parietal and coelomic portions of about the same diameter. The spermathecal diverticulum which passes into the median face, anteromedian aspect (Baling worms) or the anterior face of the duct (Kaki Bukit worms) close to the parietes always reaches up beyond the ental margin of the ampulla. An ectal portion of variable length has a smooth surface and muscular sheen, is circular in cross section, the lumen irregular as a result of the presence of longitudinal ridges. A middle portion sharply constricted off from the ellipsoidal seminal chamber is flattened, usually wider than the seminal chamber, softened and usually with a slightly translucent appearance. Slight incisions of the margins indicate a regularly zigzagged looping, all of the loops short, in the same plane, the limbs of the loops in contact. In this portion of the diverticulum the longitudinal ridges appear to be quite irregular and occasionally in contact centrally if not actually united. In the Baling specimens the middle portion of the diverticulum is long, the stalk proper quite short. In the Kaki Bukit specimens the stalk proper is longer, the softer middle portion correspondingly shortened, occasionally quite short though always present.

Parasites.—One Baling specimen has in the coelomic cavities numbers of cysts, numbers of vermiform gregarines and several

nematodes. A worm from Kaki Bukit has more than forty nematodes in the coelomic cavities of the first forty segments.

Remarks.—All of the specimens are more or less macerated, in best condition subneural trunk and lymph glands unrecognizable. In spite of the poor condition it is improbable that the unpaired condition of the testis sacs in the majority of the Baling worms is fictitious, *i.e.*, the result of maceration or inability to recognize the median partitions as some of the Kaki Bukit specimens are just as macerated and yet in each of these worms a median interval between the two sacs of a segment is recognizable and two distinct membranes between the paired masses of testicular coagulum. Whether local peculiarities of spermathecal diverticula are to be regarded as due to maceration is not clear.

The Malayan worms differ from Burmese specimens of *mamillana* as follows: smaller size, slightly smaller setal numbers, unpaired testis sacs, modification of a middle portion of the spermathecal diverticula (?), median or anterior junction of the diverticulum with the spermathecal duct, and also with regard to the size (and possibly structure?) of the male porophores as well as the number and location of the genital markings in the copulatory chambers. However differences from Burmese worms are not uniform (except as regards the middle region of the spermathecal diverticula). Perlis specimens have the usual paired testis sacs while the Baling specimens have unpaired sacs. Spermathecae of the Perlis specimens are more like those of Burmese worms while the male porophores of the Baling worms are more like those of Burmese worms. Genital markings except those associated with the male porophores, in worms from both localities, may be as in the Burmese worms though not on ends of protuberant columns. Size and setal differences do not appear to be especially significant. Differences between Kaki Bukit and Baling specimens do not warrant specific separation. Divergence from Burmese forms may in part be due to activities of parasites.

Burmese and Malayan forms appear to be both distinguishable from *P. perichaeta* (Beddard) 1900, known only from Patalung in a southern Siamese portion of the peninsula, by spermathecal characteristics. Unfortunately nothing is known of the copulatory chambers in the Siamese species.

Pheretima strellana n.sp.

Baling, Kedah. 12/1938. 9 clitellate specimens.

External characteristics.—Length 46–62 mm. Diameter two to three mm. Pigmentation red, restricted to the dorsum, sparse, especially so or lacking posterior to the clitellum.

EARTHWORMS FROM PERLIS AND KEDAH

SETAL FORMULAE

vi	vii	viii	xvii	xviii	xix	ii	iii	iv	viii	xii	xx
21	23	23	17	14	17	21+	26	30	46	..	43
19	21	23	16	13	16	14+	28	35	45	46	47
18	21	19	17	13	16	13+	27	33	42	47	44

The first dorsal pore is on 12/13 (3, but with a rather pore marking marking on 11/12 on two of the specimens).

The clitellum is dark grey, annular, extending to 13/14 and 16/17; intersegmental furrows, dorsal pores and setae lacking. Spermathecal apertures are transversely placed slits on 5/6-8/9, slightly less than $\frac{1}{2}$ C apart.

The single female pore is median (5).

Apertures of the copulatory chambers are transversely placed slits in the setal circle of xviii.

Genital markings are circular (or almost so) tubercles, slightly raised, one to two intersetal intervals wide, each marking with a large, greyish translucent central area surrounded by a narrow, opaque marginal band more or less indistinctly demarcated peripherally. Markings are in transversely placed rows, of two to five on the preclitellar segments, of two to seven on the postclitellar segments (occasionally a single marking instead of a row) and are located as follows: presetal and postsetal on viii and ix (1 specimen); presetal on viii and ix, postsetal on ix (6); presetal and postsetal on ix, a single presetal marking on viii on the left side (1); presetal and postsetal on ix (1); presetal on xix-xxii (2); presetal on xix-xxiii (7); a single presetal marking present on xviii of one specimen, on xxiv of another; postsetal on xxii (9); postsetal markings also present on xxi (1) or xxiii (4). Each presetal (post-clitellar) row may be of five markings or the number may decrease from seven on xix to two on the last segment. In the postsetal row on xxii there are two, four, five, six or seven markings; on xxii two markings, one or two on xxiii.

Internal anatomy.—Septa 8/9-9/10 are lacking; none of the septa especially muscular. The mid-dorsal stripe is pigmented, a brilliant red, and may be recognizable anteriorly into x.

The inner wall of the oesophagus in x-xiii is provided with the usual ridges, all white. Between the ridges in xii of one specimen there are numerous tiny, calcareous granules. The intestine begins in xv (4). The intestinal caeca are simple, the margins with slight septal incisions. The typhlosole begins abruptly just in front of the caecal apertures and is high,

lamelliform, gradually decreasing in height posteriorly, unrecognizable behind lv (specimen with 86 segments). A low and interrupted glandular collar is probably present on the oesophagus just behind the gizzard in one specimen but is unrecognizable in other worms. The soil in the gut is of a brick-red colour.

The dorsal blood vessel (single) is recognizable anteriorly nearly to the cerebral ganglia. A supra-oesophageal trunk is recognizable only between the hearts of x-xiii. The extra-oesophageal trunks are recognizable from 5/6 into xii or xiii. A subneural trunk is quite unrecognizable in each of the dissected specimens. Hearts of xi-xiii bifurcate dorsally, the anterior branch passing to the supra-oesophageal trunk, the slender posterior branch to the dorsal trunk. Hearts of x have been traced only to the supra-oesophageal. The single heart of ix is on the left or the right side. All hearts of ix-xiii pass into the ventral trunk. Last hearts in xiii (4). Lymph glands are quite unrecognizable. Blood glands or structures recognizable as such, are present in v of only one specimen.

The testis sac of x is annular, not markedly lobed, passing across the dorsal blood vessel, the hearts of x included. The testis sac of xi apparently is cylindrical, the seminal vesicles of xi included, in contact with each other above the dorsal trunk, adherent to the gut mesially by delicate, transparent strands, separated from the wall of the sac by a thin, annular band of testicular coagulum. Hearts of xi are bound to the anterior face of 11/12. The prostatic duct is $1\frac{1}{2}$ mm. long, with muscular sheen, in a J-shaped loop, the long limb passing from the gland mesially in an anterior portion of xviii, curving laterally to open through the dorsal face of the copulatory chamber. The vas deferens passes into the ental end of the prostatic duct. The copulatory chamber is small, concealed beneath connective tissue and an ectal portion of the prostatic duct. The lumen is nearly filled by a rather slender penis, about $\frac{1}{2}$ mm. long, slightly but gradually thickened dorsally, the minute male pore at the ventral end.

The spermathecal duct is much shorter than the rather long ampulla, with muscular sheen, circular or nearly so in cross section, the coelomic and parietal portions of about equal length, slightly though abruptly narrowed just prior to entrance into the parietes. The lumen of the ental portion is transversely slit-like to shortly elliptical in cross section, just ectal to the diverticular junction very narrow and circular in cross section, further ectally transversely slit-like in cross section. The two portions of the duct are in communication with each other through a minute pore at the centre of a tubercle with circular

outline and regularly convex, smooth surface, the tubercle at the ectal end of the chamber (not on the lateral or mesial wall). The diverticulum which passes to the median face of the duct fairly close to the parietes comprises an ovoidal, ellipsoidal, pyriform or irregular seminal chamber and a slender stalk which is shortly looped, the loops open or with limbs in contact, the diverticulum reaching up onto the ectal half of the ampulla.

Genital marking glands are shortly stalked and erect in the coelomic cavities.

Remarks.—As a possible result of maceration genital markings are difficult to recognize, usually invisible until after removal of cuticle. In spite however of the small size, genital markings must be considered as relatively rather large extending anteroposteriorly fairly close to the intersegmental furrows and setal circles.

P. strellana is distinguished from the octothecal penile species of the northern states to which it is most closely related by the distribution of the genital markings.

Diagnosis.—Octothecal; spermathecal apertures fairly widely paired, transversely placed slits on 5/6–8/9. Male pores minute, each pore at ventral end of $\frac{1}{2}$ mm. long, slender penis on roof of small copulatory chamber. Genital markings circular tubercles in transversely placed rows; presetal on viii–ix, xix–xxiii (xxiv), postsetal on (viii) ix, xxii (xxiii). Setae: vi/18–21, vii/21–23, viii/19–23, xvii/16–17, xviii/13–14, xix/16–17, 26–28/iii, 30–35/iv, 42–46/viii, 46–47/xii, 43–47/xx. First dorsal pore on 12/13. Length 46–62 mm. Diameter 2–3 mm.

Intestinal caeca simple. Testis sac of x annular, of xi cylindrical. Spermathecal duct much shorter than ampulla, ental chamber about as long as rest of duct and opening ectally through a transversely placed papilla; diverticulum with slender, shortly looped stalk to median face of duct close to parietes and a simple seminal chamber reaching onto ectal half of ampulla. Genital marking glands stalked and coelomic.

Distribution.—Known only from the type locality, Baling, in Kedah.

Genus *Dichogaster* Beddard

Dichogaster saliens (Beddard).

Microdrilus saliens Beddard 1893, Proc. Zool. Soc. London, 1892, p. 683. (Types in the British Museum? Type locality undesignated, original specimens from Singapore, Penang and Java, in part at least via Kew Gardens.)

Cameron Highlands, Pahang. 1 acitellate and 15 clitellate specimens.

G. E. GATES

Family GLOSSOSCOLECIDAE

Subfamily GLOSSOSCOLECINAE

Genus Pontoscolex Schmarda

Pontoscolex corethrurus (Fr. Müller).

Lumbricus corethrurus Fr. Müller 1857, Arch. Natg. XXIII, p. 113.
(Types? Type locality, Itajaby, Brazil.)

Lowland jungle. Gunong Panti, Johore. 3/1938. 11
juvenile, 9 acitellate and 13 clitellate specimens.